Chevron

human energy

Loading Arm Replacement Project Lessons Learned

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Loading Arm Replacement Project

Lessons Learned

Original Arms

Replacement Arm Design and Fabrication

- Factory Inspection / QC

Transportation

Construction

- Removal of Existing Arms
- Replacement Arm Installation
- Hydraulics and PLC Controls

Operability Improvements

Acknowledgments

Existing Loading Arms - DCMAs

- **Wharf Overview**
- Largest marine oil terminal on west coast
- Import refinery crude and feedstocks
- Export products
- Constructed in 1940s
- Modernized in 1970s/1990s
- Dated berthing configuration

- **Marine Loading Arm (MLA) History**
- Double counterweight marine loading arms (DCMA)
- Installed in 1973
- Refurbished from other facility
- 66% Availability (Berth 1 and 4)
- Obsolete design

New Loading Arms – Design Drivers

1. Structural Loading

To avoid additional pile driving, CVX used existing loading arm foundations.

Decision: Selected Rotating Counterweight Marine Arms (RCMAs) instead of Double Counterweight Marine Arms (DCMAs) to reduce equipment weight

2. Current velocity < 1.5 kt

Decision: No Emergency Release Couplings (ERCs) required, which would have dramatically increased the structural pile driving necessary at each berth due to their weight.

3. Manufacturer selection

Chevron competitively bid loading arms with 3 different manufacturers.

Decision: Went with same manufacturer of existing arms

4. Fabrication / Installation Schedule

Timing of planned Berth 4 shutdown (45 days, 4Q2016) drove phased production of loading arms by berth, enabling Chevron to incorporate lessons learned into the arm design, transport and installation at the subsequent berths.

5. MOTEMS compliant for sea level rise accommodation (16” by 2050)

Replacement Arm Design and Fabrication

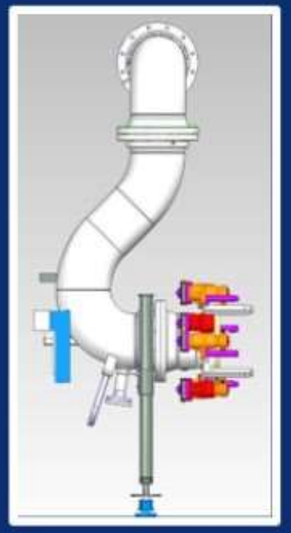
Lessons Learned

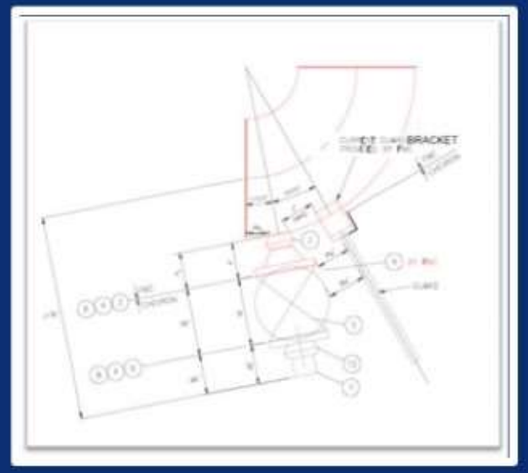
Design

Use existing foundations
- – RCMA weighs less than DCMA

RCMA has greater operating envelope
- – Can accommodate more modern vessels

RCMA needs greater footprint to operate
- – Structural extension of Berth 3 (3 ft.)
- – Addition of Berth 1 drip pan





Vendor-proposed low point drain (left) vs. CVX "lowest point" drain (above).

Quality

Location of nozzles on RCMA
- – Not true low point → up to 2 gallons of product
- – Miss-alignment of inboard arm outlet nozzle
- – **Result:** Additional verification of critical dimensions by 3rd party inspector

Bolt pattern on cover plate interfered with ring seal

Inconsistent supplier torque values & torque procedures
- – Leaky joints and loose fittings
- – **Result:** Retorqued joints prior to installation

Supplier did not follow their own QC procedure
- – **Result:** Hired 2 additional Quality Engineers to support project

Additional Inspection

Retained expeditor for B4 RCMA to keep schedule

100% vs 20% x-ray of full penetration welds
- – Paid premium to supplier to prioritize inspection to meet schedule
- – City of Richmond weld inspector onsite to inspect structural welds
- – Supplier became CoR approval fabricator for this job only.

Positive Material Identification (PMI)

Transportation

Schedule-driven choices and lessons learned

Needed 6 week (max) transit from Europe to USWC:

- Truck from Sens, France → Zeebrugge, Belgium
- Shipping: Zeebrugge → Pt. Hueneme using Ro/Ro
- Truck from Pt. Hueneme → Alameda
- Barge from Alameda → RLW by barge

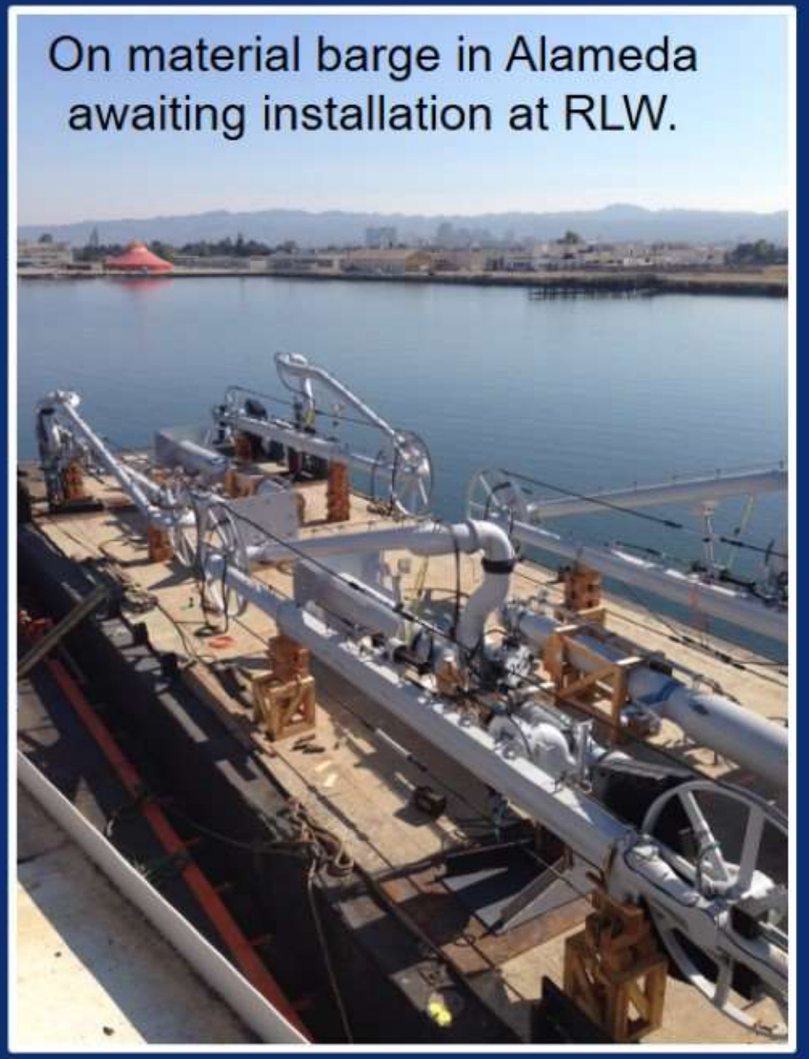
Five (5) lifts per arm.

Lessons learned as a result of Berth 4:

- Contract logistics coordinator with international experience.
- Marine surveyor (inspector)
- Reinforced crating with double cross braces
- Shock watch
- Tie-down strap angles verified for trucking
- Additional padding/carpet at points of contact.

Transportation

Schedule-driven choices and lessons learned



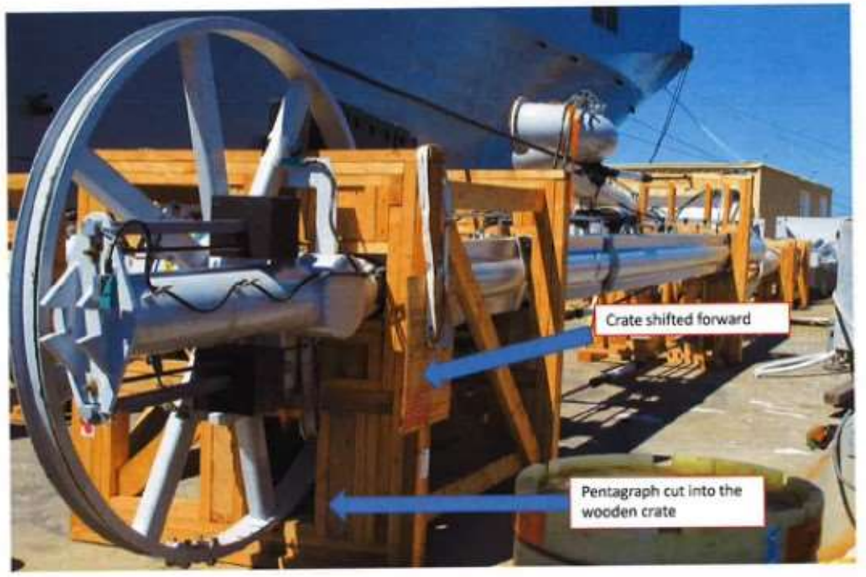
Transportation

Schedule-driven choices and lessons learned

Chevron Delivery of Berth 4 Arms

RCMA 2

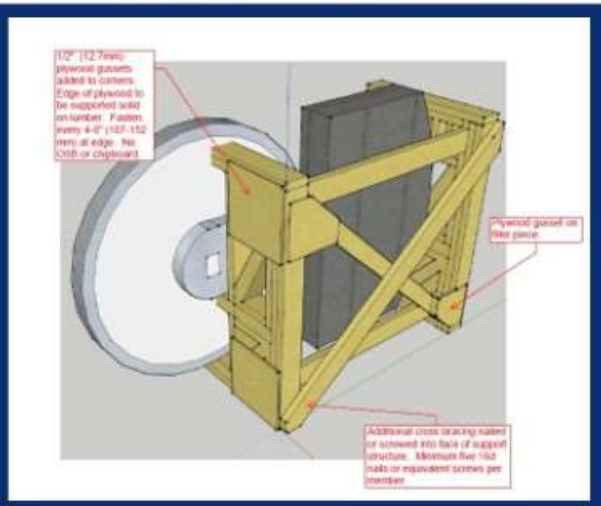
The arm showed up with the pentagraph sitting on the wood blocking below indicating that the crate shifted forward during transit. After un-crating, no damage to the pentagraph was observed.

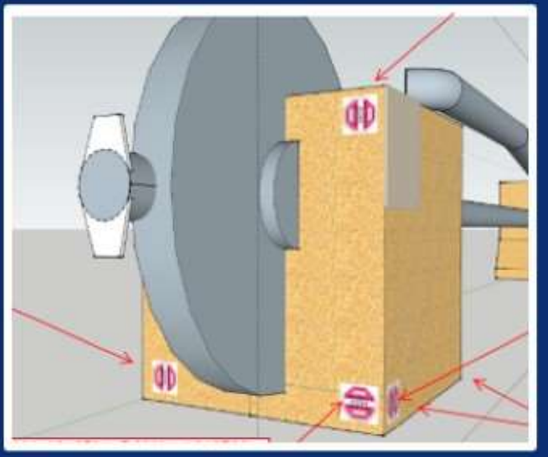


Chevron Delivery of Berth 4 Arms

RCMA 5

Crate failed moving laterally.





Construction – Execution Planning

Phased Approach – Berth 4, then 3 and 1.

Pre-Shutdown Work

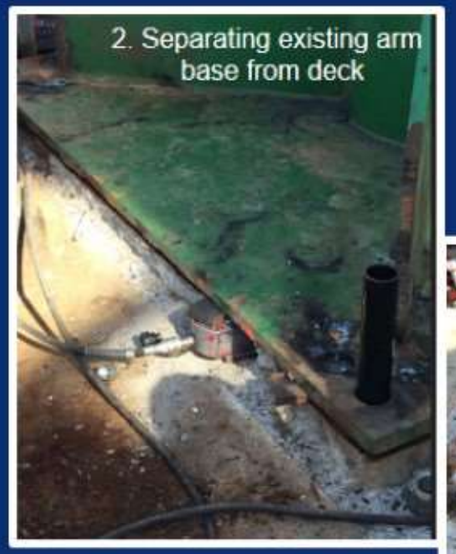
- Structural
- Removed OOS DCMAs
- Rerouting of utility lines

Berth 4 – 45/60 day shutdown

- Continuous window enabled troubleshooting.
- 4 arms removed during shutdown.
- Structural work done before shutdowns began.

Berth 3 and 1 – Done in parallel

- 3-5 day natural window outages vs. 10 day planned shutdowns
- 2 arms removed at a time, 2 arms set in position.
- Compressed schedule
- Friday / Saturday work as needed.
- Electrical / tubing work completed as SimOps.
- Mobile hydraulic oil pre-filter/testing lab on site
- Arm installation timeframe reduced by 3 days per arm.



Construction

General

General contractor attended training and FAT at supplier

Non-Shutdown work at various berths are worked in parallel to

- Minimize down time or demobilization from RLW
- Maintain dedicated crew

Phase approach to allow incorporation of lessons learned from Berth 4 into Berth 3 and 1

Base riser lift at Berth 4

Construction

Removal and Installation of MLAs

B4 has dedicated continuous outage window (45 Days Planned vs 60 Days Actual)

- OOS DCMA was removed during pre-work
- Temp support of operating platform

B1 and B3 are in operation during construction

- Use “natural windows” to remove DCMA during pre-work
- Working Fridays and/or Saturdays as needed
- SimOps: electrical and tubing work
- Each outage is planned for removal and installation 2 MLAs

MLAs needs to be pre-balance before installation

Lifting and setting outboard arm – Berth 4

Construction – Hydraulic System

New Hydraulic System Design

- Isolated hydraulic circuit (CVX design) to minimize down time during repair
- Two layers of protection to prevent operating arm by mistake

Lessons Learned

- LOTO MLAs that are not in operation
- Mobile hydraulic lab to clean hydraulic oil to NAS class 9
- Biodegradable hydraulic fluid
  - Shipped to loading arm supplier for Factory Acceptance Test

Hydraulic manifold to isolate circuits on arm, enabling maintenance to drain one hydraulic cylinder at a time. versus entire arm or common header.

Construction – Controls

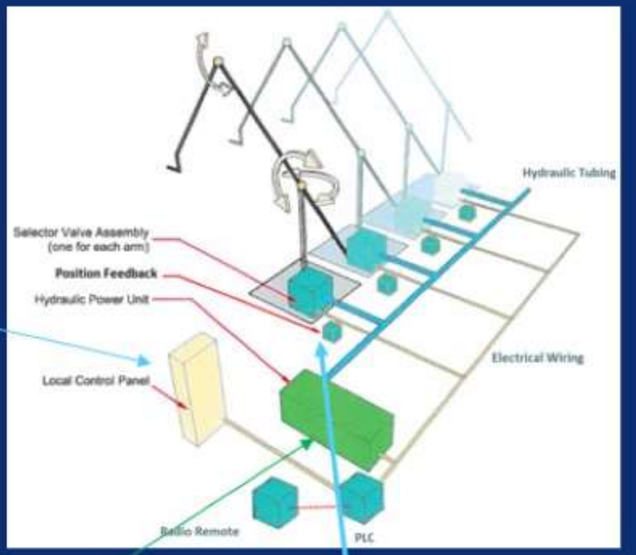
New Control System

- Remote Controlled (preferred)
- Local Control Panel (LCP)
- Selector Valve Assembly (SVA)

Lessons Learned

- Added universal remote (3 Berths)
- Miscommunication between supplier and sub-vendor caused frequent drop of radio signal
- Supplier did not test out all functionality of remote controller
- Added additional test functions on LCP

Radio Remote



Hydraulic Power Unit

Selector Valve Assembly

Operability Improvements

Improved Efficiency Beyond Expectations

45 minute connection time reduced to 7 minutes.

Less reliance on ships crew for connection validation.

Operator

One operator needed (on board vessel) for connections; no longer requires two operators.

Safety

No wrenching or crow bars required for connections.

Improved Safety in Designs (SID).

Predictability

Consistent slewing distance (8.4 feet) per arm.

Berth 4

Before

After

Accomplishments

- 18 critical lifts over water
- Installed and commissioned Berth 4 MLAs (4 total) in 4Q16
- 87k+ Safe Construction Hours
- Ahead of schedule - Optimized installation of MLA by advancing schedule
- Within Budget - Potential $3MM saving in construction cost and overall capital budget

Acknowledgements

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